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BELL AEROSYSTEMS COMPANY

Report No. 2084-932-001

Date: December 1962

COMPILATION OF MATERIALS COMPATIBILITY TEST DATA WITH PROPELLANTS

Published and Distributed Under

Contract AF33(657)-8555

Bell Aerosystems Company

Division of Bell Aerospace Corporation

BELL AEROSYSTEMS COMPANY

COMPILATION OF MATERIAL COMPATIBILITY TEST DATA WITH PROPELLANTS

REPORT NO. 2084-939-001

DECEMBER 1962

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ABSTRACT

A compilation of interdepartmental communications containing materials compatibility information was made, providing greater availability of test data on properties of some metals and plastics when exposed to various rocket propellants.

Report No. 2084-939-001

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TABLES

I. INTRODUCTION

Often, in the design of hardware, certain parameters or the accumulative effect of several parameters are not available in the literature and specific tests must be performed. This is particularly true of the compatibility of materials with rocket propellants.

In the case of plastics and elastomeric materials, this is particularly applicable since the curing process, fillers used, and even the basic polymer, may vary sufficiently from one manufacturer to another to require confirmation of compatibility before approval of a material in any specific propellant.

A similar problem exists with metals since the available compatibility data often lacks information on the metal in the welded condition, with specific heat treatments or under stress.

This report is a compilation of data from interdepartmental reports to provide certain materials compatibility information under specific conditions.

II. COMPATIBILITY WITH IRFNA

Title: COMPATIBILITY OF PRC 18007 AND KEL-F NO. 5500 WITH IRFNA

Report No: 914:61:1214-1:LIF

Date: 14 December 1961

Author: L. I. Foertter

The subject elastomeric compounds were exposed to IRFNA at 70°F for two weeks. Three separately immersed test specimens, each 3 inches long, were cut from approximately 5 inch diameter by 0.15 inch thick Kel-F 35500 "0" ring (No. 117-4740317-3). One small Precision Rubber Products Corporation "0" ring (3/4 diameter by 0.0867 inch thick) designated compound 18007 was exposed separately. In addition, three specimens cut to ASTM D1457 Die Tensile Bar configuration from an approximately 0.086 inch thick Precision Rubber Products Corporation test slab, designated compound 18007 were also exposed separately to the IRFNA. Table I summarizes the test results obtained.

TABLE I

COMPATIBILITY OF ELASTOMERIC COMPOUNDS WITH IRFNA

		Original Properties	Before Outgassing	After 10 days Outgassing
Kel-F No. 5500	Hardness (Durometer "A")	61	47	61
	% Wt. Change	-	+26	+17
	% Vol. Change	-	+28	+18
	Surface Condition	ok	Bumpy	Slightly Bumpy
PRC Comp'd 18007 "O" Ring	% Wt. Change	-	+62	+24
	% Vol. Change	-	+65	+22
	Surface Condition	ok	ok	ok
PRC Comp'd 18007 Tensile Bars	Hardness (Durometer "A")	64	29	40
	% Wt. Change	-	+55	+24
	% Vol. Change	-	+61	+25
	Tensile Strength (PSI)	1458	-	550
	Elongation (%)	354	-	1114
	Surface Condition	ok	ok	ok

Title: COMPATIBILITY OF KEL-F 5500 IN IRFNA

Report No: 914:62:0502-1:BC

Date: 2 May 1962

Author: B. Castiglione

Sections of a Kel-F 5500 "O" ring were immersed in liquid IRFNA at 100°F for periods of 15 and 30 days. The sample sections were in a condition of (a) no stress; (b) stress in tension; and (c) stress in compression.

Sections designated no stress were merely straight pieces placed in the acid. Sections designated stress in tension were bent back on themselves and wired together with stainless steel wire. Sections designated stress in compression were placed between two aluminum washers and bolted together with a 25 percent compression value.

The test results are presented in Table II. All samples were bleached from gray to white but otherwise appeared unaffected.

TABLE II

KEL-F COMPATIBILITY WITH IRFNA

	Time in days	Unstressed		Tension Stress		Compression Stress	
		after test	after outgassing	after test	after outgassing	after test	after outgassing
% Weight Change	15	+13.6	+4.87	+13.8	+5.23	+17.3	+7.63
	30	+24.3	+16.3	+22.7	+15.4	+19.0	+13.0
% Volume Change	15	+29.9	+19.6	+37.5	+25.0	+35.9	+22.6
	30	+48.1	+37.2	+48.0	+29.4	+36.4	+30.1
% Durometer Change Shore "A"	15	-20.0	-23.1	-23.1	-23.1	-18.5	-23.1
	30	-30.8	-27.6	-30.8	-27.6	-30.8	-27.6

III. COMPATIBILITY WITH MON

Title: COMPATIBILITY OF FLUOREL COMPOUND KX-2141 IN MON

Report No: 914:61:0501-1:LIF:SAL

Date: 1 May 1961

Author: L. I. Foertter

A sample of 0.0884 inch thick fluorel compound KX-2141 elastomer, made by the Chemical Division of Minnesota Mining and Manufacturing Company in sheet stock form, was cut to ASTM D1457-56T Die tensile bar configuration and exposed at 40 ± 2°F in triplicate to MON of nominal 10% NO and less than 0.1% H_2O content for 31 days. Table III summarizes the data obtained.

TABLE III

COMPATIBILITY OF FLUOREL COMPOUND IN MON

	Original Properties	Immediately After Removal	After 4 Days at Room Temp. and 3 Days at 125°F Outgassing
Hardness (Durometer "A")	75 (3 Ply=71)	- -	65 (3 Ply=62)
Tensile Strength (psi)	1628	-	1303
% Elongation	290	-	462
Surface Tack	OK	OK	OK
% Change in Weight	-	218(+)	0.186 (+)
% Change in Volume	-	323 (+)	4.38 (+)

Analysis of MON After Test:

0.001% ASH , -4.0°F M.P., 8.0% NO, 0.13% H_2O

Title: COMPATIBILITY OF PRECISION RUBBER COMPOUNDS
Report No: 914:61:1228-1:BC
Date: 28 December 1961
Author: B. Castiglione

Samples of Precision Rubber Compounds 18007, 18057 and 940x559 were immersed in MON for 7 days at 35°F. They were measured for weight and volume changes and allowed to outgas for ten days before repeating the measurements. The results of the tests are presented in Table IV.

These same rubber compounds were immersed in A-50 fuel blend for 7 days at 160°F. The 18007 and 18057 compounds dissolved in less than one day. The 940x559 was measured for weight and volume after 7 days test, then allowed to outgas for 2 weeks before continuing the measurements. The results of these tests are also included in Table IV.

TABLE IV

COMPATIBILITY OF PRECISION RUBBER COMPOUNDS IN MON

	Before Outgassing		After Outgassing 10 days					
Precision Rubber Number	% Weight Change	% Volume Change	% Weight Change	% Volume Change	Tensile psi	% Elongation	Hardness	Remarks
18007 1	+154.4	+318.0	+1.03	+2.23	1215	514	55	Swells badly
2	+164.7	+323.8	+1.39	+2.61	1229	585	58	
3	+178.2	+294.2	+1.47	-0.82	1190	586	56	
Test Average	+165.7	+312.0	+1.30	+1.34	1211	562	56.3	
Control Average	-	-	-	-	1458	352	61.7	
% Change	-	-	-	-	-16.9	+58.8	-7.62	
18057 1	+106.7	186.1	+2.33	2.19	1085	221	74	Swells badly
2	+111.2	179.0	+2.00	1.89	1113	243	74	
3	+ 85.3	204.7	+1.63	1.74	-	-	-	
Test Average	+101.1	189.9	+1.99	1.94	1099	232	74	
Control Average	-	-	-	-	1349	145	75	
% Change	-	-	-	-	-18.53	+60.0	-1.33	
940x559 1	+ 36.1	+ 41.5	+4.08	+12.1	276	186	56	Many blisters
2	+ 36.1	+ 36.5	+3.96	+17.2	275	193	56	
3	+ 40.2	+ 20.7	+4.26	+17.2	256	193	58	
Test Average	+ 37.4	+ 32.9	+4.10	+15.5	269	191	56.7	
Control Average	-	-	-	-	1218	250	70	
% Change	-	-	-	-	-77.9	-23.6	-19.0	

TABLE IV (Cont)

A-50 Fuel Blend 7 Days at 160°F

	Before Outgassing				After Outgassing 2 weeks			
18007	Disintegrates Completely							
18057	Disintegrates Completely							
940x559 1	+10.5	+19.3	+5.47	+10.9	1081	314	67	Blistered
2	+10.4	+20.1	+5.50	+11.6	1058	300	67	
3	+10.6	+19.1	+5.69	+11.1	1081	286	67	Fuel clear with slight olive tint
Test Average	+10.5	+19.5	+5.55	+11.2	1073	300	67	
Control Average	-	-	-	-	1218	250	70	
% Change	-	-	-	-	-11.9	+20.0	-4.28	

Title: COMPATIBILITY OF OPALON WITH MON

Report No: 914:61:0601-1:LIF

Date: 1 June 1961

Author: L. I. Foertter

Samples of Monsanto Opalon (polyvinyl chloride) compounds 1219, 1220, and 1444, approximately 6 in. x 3 in. x 1/2 in., furnished by the Materials Research Section, were cut into coupons approximately 3 in. x 1/2 in. x 1/4 in., and tested in triplicate in MON at 40 ±2°F for 7 days and for 33 days. The results obtained are presented in Tables V and VI.

TABLE V

COMPATIBILITY AFTER 7 DAYS EXPOSURE

1.		Original	Before Outgassing	After Outgassing
Opalon 1219 Black 805	Durometer "A" Hardness	76	-	94
	% Wt. Change	-	10.09 (+)	11.17 (-)
	% Vol. Change	-	6.584 (-)	26.16 (-)
Opalon 1444 White 900	Durometer "A" Hardness	92	-	96
	% Wt. Change	-	13.14 (+)	13.84 (-)
	% Vol. Change	-	3.147 (-)	25.13 (-)
Opalon 1220 Black 800	Durometer "A" Hardness	73	-	95.7
	% Wt. Change	-	0.325 (+)	21.89 (-)
	% Vol. Change	-	14.78 (-)	35.68 (-)

TABLE VI

COMPATIBILITY AFTER 33 DAYS EXPOSURE

2.		Original	Before Outgassing	After Outgassing
Opalon 1219 Black 805	Durometer "A" Hardness	76	-	93
	% Wt. Change	-	5.939 (+)	9.785 (-)
	% Vol. Change	-	9.463 (-)	26.28 (-)
Opalon 1444 White 900	Durometer "A" Hardness	92	-	90.3
	% Wt. Change	-	3.099 (+)	11.65 (-)
	% Vol. Change	-	7.135 (-)	24.52 (-)
Opalon 1220 Black 800	Durometer "A" Hardness	73	-	96.3
	% Wt. Change	-	2.217 (-)	19.33 (-)
	% Vol. Change	-	19.71 (-)	33.95 (-)

1. Outgassed 8 days at room temperature.
2. Outgassed 4 days at room temperature.

The analyses of MON performed by the Propellants Laboratory were as follows:

	% ASH	M.P. °F	% NO	% H_2O
Original MON Used in All Exposures	0.001	-15.0	11.8	0.01
1219 Black After 7 Days	0.001	- 5.0	8.3	0.13
1244 White After 7 Days	0.001	-13.0	11.2	0.11
1220 Black After 7 Days	0.001	- 2.5	7.5	0.09
1219 Black After 33 Days	0.001	-12.0	11.0	0.23
1244 White After 33 Days	0.001	-13.0	11.2	0.26
1220 Black After 33 Days	0.001	-15.0	11.8	0.19

Note: A heavy oily residue (after evaporation in the % Ash analysis) burned on ignition, giving a normal % Ash result. This residue was weighed before ignition (on the 7-day samples only) with the following results;

	% Residue After Evaporation
1219 Black After 7 Days	1.03
1244 White After 7 Days	2.28
1220 Black After 7 Days	1.63

Title: COMPATIBILITY OF FLUORINATED PLASTIC SHEET STOCK IN MON

Report No: 914;61;0501-2:LIF:SAL

Date: 1 May 1962

Author: L. I. Foertter

Samples of 0.0040 inch thick polyvinyl fluoride (DuPont's "Teslar 30") and 0.0105 inch thick polyvinylidene fluoride (Pennsalt's "Kynar") plastic sheet stock, provided by the Materials Research Section, were cut to ASTM D1457-56T die tensile bar configuration and exposed at 40 ± 2°F in triplicate to MON of nominal 10% NO and less than 0.1% H_2O content for 31 days. In addition to the data thus obtained and presented in Tables VII and VIII, 3 inch x 3 inch pieces of these two fluorinated plastic sheet stocks were permeability tested also.

The transmission rates were obtained with a differential pressure of 17 to 18 psi at 76°F; values were calculated to 0°C.

Pennsalt Kynar (Polyvinylidene Fluoride)

Air 5.2cc/100 sq in./24 hours
MON 1031.8cc/100 sq in./24 hours

Teslar 30 (Polyvinyl Fluoride)

Air 7.6cc/100 sq in./24 hours

MON *

*Material is not compatible with MON in that it absorbs MON and allows the passage of gas within seconds. The original thickness of 4 mils increased to 4.3 mils after test, and the material felt soft and spongy.

TABLE VII

AVERAGED RESULTS FOR POLYVINYL FLUORIDE (TESLAR 30)

	Original Properties	Immediately After Removal	After 4 Days at Room Temp & 3 Days at 125°F Outgassing
Hardness (Durometer "D")	96 (3 ply=89)	- -	96 (3 ply=88)
Tensile Strength (psi)	1396	-	1316
% Elongation	89	-	103
Surface Tack	OK	OK	OK
% Change in Weight	-	29.3 (+)	No change
% Change in Volume	-	20.6 (+)	0.84 (+)

Analysis of MON After Test:

0.002% ASH, -6.0°F M.P., 8.6% NO, 0.23% H_2O

TABLE VIII

AVERAGED RESULTS FOR POLYVINYLIDENE FLUORIDE
(PENNSALT KYNAR)

	Original Properties	Immediately After Removal	After 4 Days at Room Temp . 3 Days at 125°F Outgassing
Hardness (Durometer "D")	89 (3 ply=73)	- -	89 (3 ply=73)
Tensile Strength (psi)	699	-	627
% Elongation	403	-	293
Surface Tack	OK	OK	OK
% Change in Weight	-	11.6 (+)	0.017 (-)
% Change in Volume	-	64.3 (+)	0.159 (-)

Analysis of MON after Test:

0.001% ASH, -5.0°F M.P., 8.3% NO, 0.13 % H_2O

IV. COMPATIBILITY WITH HYDROGEN PEROXIDE

Title: COMPATIBILITY OF POLYVINYL CHLORIDE RUBBER AND POLYETHYLENE FOAM WITH 90% HYDROGEN PEROXIDE

Report No: 924:60:1020-1

Date: 20 October 1960

Author: L. D. Nasiak

A. GENERAL

The following materials were submitted for test:

(1) Rubatex, R-310V Polyvinyl Chloride Rubber

(2) Ensolite, Polyvinyl Chloride Rubber

(3) Polyethylene Foam, Dow Chemical Company

B. MATERIAL COMPATIBILITY

The above materials were immersed individually in 90 percent hydrogen peroxide at ambient temperature. Upon initial contact, no visible reaction occurred. After a 5-minute retention period, several bubbles were slowly being formed on the surface of the materials. This action proceeded for the required test period of 24 hours. The samples were removed from the peroxide and the following observations were noted:

(1) Both vinyl rubbers retained most of their resiliency but suffered a marked decrease in tensile strength. They swelled to approximately 150 percent of their original volume. The colors were bleached from a tan to a light tan, approaching white.

(2) The polyethylene foam retained a substantial part of its original resiliency and tensile strength. There was no apparent swelling. The color was slightly bleached from a gray-black to a gray.

C. SHOCK SENSITIVITY

The apparatus used to determine the sensitivity to impact was an Olin-Mathieson Impact Sensitivity Tester. Table IX presents average values obtained from numerous drop tests. The impact sensitivity values for TNT, RDX, and lead azide are included for comparison. The specific values are only valid for the Olin-Mathieson tester.

D. CONCLUSION

At no time during impact testing of the submitted samples did an explosion occur. Positive results were taken at the point at which definite discoloration of the samples was apparent.

TABLE IX

IMPACT SENSITIVITY WITH 90% HYDROGEN PEROXIDE

A. Polyvinyl Chloride Rubbers.

The following results are applicable both to the Rubatex and Ensolite samples.

	Materials Tested	Impact Sensitivity Inch-Ounces	Comments
1.	Virgin Rubbers	6992	Very insensitive to shock.
2.	Rubbers after 24-hr soak period in 90% H_2O_2, squeezed dry, test run.	5520	Quite insensitive to shock.
3.	Rubbers after 24-hr soak period in 90% H_2O_2, then soaked in water for 10 min, squeezed dry, test run.	6256	Very insensitive to shock.
4.	Rubbers after 24-hr soak period in 90% H_2O_2, then soaked in water for 10 min, air dried for 24 hrs, test run.	4600	Shock sensitivity is increasing.
5.	Rubbers after 24-hr soak period in 90% H_2O_2, then soaked in water for 10 min, dried at 122°F for 24 hrs, test run.	3220	Approaching the lower limits of shock sensitivity.

TABLE IX (Cont)

IMPACT SENSITIVITY WITH 90% HYDROGEN PEROXIDE

	Materials Tested	Impact Sensitivity Inch-Ounces	Comments
6.	TNT	3000	Quite shock sensitive.
7.	RDX	1340	Quite shock sensitive.
8.	Lead Azide	720	Very shock sensitive.
	B. Polyethylene Foam.		
1.	Virgin Foam	> 5520	Very insensitive to shock.
2.	Foam after 24-hr soak period in 90% H_2O_2, squeezed dry, test run.	> 5520	Very insensitive to shock.
3.	Foam after 24-hr soak period in 90% H_2O_2, then soaked in water for 10 min, dried at 122° F for 6 hrs, test run.	> 5520	Very insensitive to shock.

Title: COMPATIBILITY OF 17-4 PH STAINLESS STEEL WITH 90% HYDROGEN PEROXIDE

Report No: 914:62:0628-1:FRP

Date: 28 June 1962

Author: F. Piccirillo, B. Castiglione

The compatibility of 17-4 PH stainless steel was determined at various hardness of material conditions at ambient temperature and 151°F for 7 days. Forty two cc of H_2O_2 were used for each square inch of surface area. This S/V is recommended in the Becco Manual No. 104. The results are presented in Table X.

TABLE X

COMPATIBILITY DATA FOR 17-4 PH STAINLESS STEEL AND 90% HYDROGEN PEROXIDE

	Ambient Temperature Specimen No. and Rockwell Hardness			151°F Specimen No. and Rockwell Hardness		
Time Interval Analysis	1 Rc 34	3 Rc 41.5	5 Rc 43	2 Rc 34	4 Rc 40.5	6 Rc 43
Initial H_2O_2 Analysis	90.7%	90.7%	90.7%	90.7%	90.7%	90.7%
44 hours	90.7%	90.7%	90.6%	90.4%	89.2%	89.5%
116 hours	90.6%	90.5%	90.6%	89.9%	83.7%	84.7%
168 hours	90.5%	90.5%	90.2%	88.1%	56.5%	76.9%
212°F Stability	90.24%	94.76%	95.80%	21%	0%	0%
Observations Immediately after Test	material clean	material clean	material clean	material clean	material clean	material clean
Observation After 24 hour Air Dry	material slightly tarnished	material slightly tarnished	material slightly tarnished	material heavily bronzed	material heavily bronzed	material heavily bronzed

The results obtained indicate:

(1) 17-4 PH stainless steel is not compatible with 90% hydrogen peroxide.

(2) From the elevated temperature compatibility results, it can be categorized as a Class 4 material (Not to be used for H_2O_2 Service)

(3) The ambient temperature results indicate its feasibility for use, however, classification is dependent upon the elevated temperature results.

V. MISCELLANEOUS COMPATIBILITY INFORMATION

BELL AEROSYSTEMS COMPANY

Title: COMPATIBILITY OF TEFLON SPECIMENS WITH HYDRAZINE AND UDMH AT ELEVATED TEMPERATURES

Report No: 914:61:0901-1:BC

Date: 1 September 1961

Author: B. Castiglione

Three grades of teflon strips were immersed separately in anhydrous hydrazine and UDMH for 120 hours at 160°F. These grades included teflon TFE, teflon FEP and a 5 mil TFE - 5 mil FEP laminates. The physical properties determined were weight change, volume change, tensile and elongation changes and fuel analysis before and after test. These are included in Table XI. There was no blistering of the teflon surface.

TABLE XI

EFFECT OF TEFLON STRIPS IMMERSED 120 HOURS AT 160°F

Teflon	% Weight Change	% Volume Change	% Tensile Change	% Elongation Change	Fuel Analysis Before Test N_2H_4 97.55	UDMH 98.78
					After Test	
TFE	+0.31	+1.65	-5.59	-0.53	-	97.25
FEP	-0.02	0.0	+0.47	-1.07	-	96.69
Laminate	+0.24	+0.64	-9.57	-1.04	-	96.07
TFE	+0.05	+3.06	+0.65	+5.30	97.47	-
FEP	-0.17	+0.64	-3.17	-2.94	97.26	-
Laminate	+0.10	+0.23	-6.31	-1.04	97.35	-

Title: COMPATIBILITY OF TEFLON COATED 17-7 PH STEEL WITH MON AND UDMH

Report No: 914:61:1228-2:BC

Date: 28 December 1961

Author: B. Castiglione

Specimens of primer plus black, primer plus green and primer plus clear samples of teflon coated 17-7 PH steel were immersed in MON at 40°F and UDMH at room temperature for a 7 day test period. The weight changes are:

	Primer + Clear	Primer + Green	Primer + Black
MON	+0.076	+0.132	+0.078
UDMH	+0.092	+0.017	+0.045

There was no change in dimensions, no leaching of the pigment, and no loss of adhesion of the coating from the metal.

Title: COMPATIBILITY OF VARIOUS ELASTOMERS WITH N_2H_4/MMH/H_2O FULL BLEND

Report No: 964:61:0309-1:WHW/CT

Date: 9 March 1961

Author: W. H. Walters

The following elastomers were tested in a 4:4:1 mole ratio N_2H_4: monomethylhydrazine: H_2O fuel blend:

Vendor	Type Material	Comp'd No.
1. Plastic & Rubber	Viton A	945-70
2. Plastic Products Co. (Parco)	Viton	920-70
3. Plastic Products Co. (Parco)	Butyl	838-80
4. Precision Rubber Co.	Viton	17107
5. Precision Rubber Co.	Silicone	11536

The "0" ring specimens were exposed to the fuel blend for a limited period of time at ambient temperature, 70° - 75°F. Initially the specimens were completely submerged. No weights or measurements were recorded.

After 2 to 3 days, the viton and silicone specimens (4 specimens) were completely deteriorated (gross swelling and complete loss of physical properties). Conclusion: completely unsatisfactory for service in subject fuel blend.

After 3 weeks, the butyl specimen still looks satisfactory. It is suggested that more elaborate tests be authorized to determine use limits of the Butyl Compound No. 838-70 (Precision).